

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

United States Patent and Trademark  
Office  
(Box PCT)  
Crystal Plaza 2  
Washington, DC 20231  
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

<b>Date of mailing (day/month/year)</b> 08 March 1999 (08.03.99)	<b>Applicant's or agent's file reference</b>
<b>International application No.</b> PCT/AU98/00576	<b>Priority date (day/month/year)</b> 23 July 1997 (23.07.97)
<b>International filing date (day/month/year)</b> 22 July 1998 (22.07.98)	
<b>Applicant</b> KHOE, Ging, Hauw et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

22 February 1999 (22.02.99)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was  
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

<b>The International Bureau of WIPO</b> 34, chemin des Colombettes 1211 Geneva 20, Switzerland	<b>Authorized officer</b> C. Carrié
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

## PATENT COOPERATION TREATY

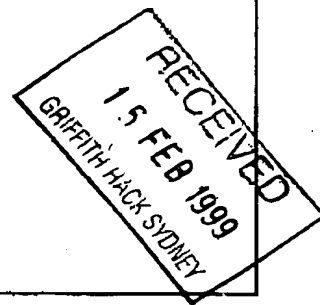
PCT

From the INTERNATIONAL BUREAU

NOTICE INFORMING THE APPLICANT OF THE  
COMMUNICATION OF THE INTERNATIONAL  
APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:

GRIFFITH HACK  
Level 8  
168 Walker Street  
North Sydney, NSW 2060  
AUSTRALIE

Date of mailing (day/month/year)

04 February 1999 (04.02.99)

Applicant's or agent's file reference

## IMPORTANT NOTICE

International application No.

PCT/AU98/00576

International filing date (day/month/year)

22 July 1998 (22.07.98)

Priority date (day/month/year)

23 July 1997 (23.07.97)

Applicant

CRC FOR WASTE MANAGEMENT &amp; POLLUTION CONTROL LIMITED et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:

AU,BR,CN,EP,IL,JP,KP,KR,US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:

AL,AM,AP,AT,AZ,BA,BB,BG,BY,CA,CH,CU,CZ,DE,DK,EA,EE,ES,FI,GB,GE,GH,GM,HR,HU,ID,IS,  
KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,  
SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZW

The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on 04 February 1999 (04.02.99) under No. WO 99/05065

## REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

## REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland

Authorized officer

J. Zahra

Facsimile No. (41-22) 740.14.35

Telephone No. (41-22) 338.83.38

# PCT

## REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference  
(if desired) (12 characters maximum)

**Box No. I TITLE OF INVENTION**

Photo-Assisted Oxidation of Inorganic Species in Aqueous Solution

**Box No. II APPLICANT**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

CRC for Waste Management & Pollution Control Limited  
Botany Street, Gate 11  
The University of NSW  
KENSINGTON NSW 2033  
AUSTRALIA

☐ This person is also inventor.

Telephone No.

+612 9385 4886

Facsimile No.

+612 9662 1971

Teleprinter No.

State (that is, country) of nationality:

AUSTRALIA

State (that is, country) of residence:

AUSTRALIA

This person is applicant for the purposes of:

☐

all designated States

☒

all designated States except the United States of America

☐

the United States of America only

☐

the States indicated in the Supplemental Box

**Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

Australian Nuclear Science and Technology Organisation  
New Illawarra Road  
LUCAS HEIGHTS NSW 2234  
AUSTRALIA

This person is:

☒ applicant only

☐ applicant and inventor

☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

AUSTRALIA

State (that is, country) of residence:

AUSTRALIA

This person is applicant for the purposes of:

☐

all designated States

☒

all designated States except the United States of America

☐

the United States of America only

☐

the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

**Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE**

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:

☒

agent

☐

common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

GRIFFITH HACK  
Level 8  
168 WALKER STREET  
NORTH SYDNEY NSW 2060

Telephone No.

9957 5944

Facsimile No.

9957 6288

Teleprinter No.

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

KHOE Ging Hauw  
125 Nicholson Pde  
CRONULLA NSW 2232  
AUSTRALIA

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

AUSTRALIA

State (that is, country) of residence:

AUSTRALIA

This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

ZAW Myint  
41 Delhi Street  
LIDCOMBE NSW 2141  
AUSTRALIA

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

AUSTRALIA

State (that is, country) of residence:

AUSTRALIA

This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

PRASAD Patricia Salini  
604 Woodville Road  
GUILDFORD NSW 2161  
AUSTRALIA

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

AUSTRALIA

State (that is, country) of residence:

AUSTRALIA

This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

EMETT Maree Therese  
17 Stevens Street  
PENNANT HILLS NSW 2120  
AUSTRALIA

This person is:

- ☐ applicant only  
☒ applicant and inventor  
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

AUSTRALIA

State (that is, country) of residence:

AUSTRALIA

This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

**Box No.V DESIGNATION OF STATES**

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

**Regional Patent**

- ☒ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

**National Patent (if other kind of protection or treatment desired, specify on dotted line):**

- |  |  |
|--|--|
| <input checked="" type="checkbox"/> AL Albania                               | <input checked="" type="checkbox"/> LS Lesotho                                   |
| <input checked="" type="checkbox"/> AM Armenia                               | <input checked="" type="checkbox"/> LT Lithuania                                 |
| <input checked="" type="checkbox"/> AT Austria                               | <input checked="" type="checkbox"/> LU Luxembourg                                |
| <input checked="" type="checkbox"/> AU Australia                             | <input checked="" type="checkbox"/> LV Latvia                                    |
| <input checked="" type="checkbox"/> AZ Azerbaijan                            | <input checked="" type="checkbox"/> MD Republic of Moldova                       |
| <input checked="" type="checkbox"/> BA Bosnia and Herzegovina                | <input checked="" type="checkbox"/> MG Madagascar                                |
| <input checked="" type="checkbox"/> BB Barbados                              | <input checked="" type="checkbox"/> MK The former Yugoslav Republic of Macedonia |
| <input checked="" type="checkbox"/> BG Bulgaria                              |  |
| <input checked="" type="checkbox"/> BR Brazil                                | <input checked="" type="checkbox"/> MN Mongolia                                  |
| <input checked="" type="checkbox"/> BY Belarus                               | <input checked="" type="checkbox"/> MW Malawi                                    |
| <input checked="" type="checkbox"/> CA Canada                                | <input checked="" type="checkbox"/> MX Mexico                                    |
| <input checked="" type="checkbox"/> CH and LI Switzerland and Liechtenstein  | <input checked="" type="checkbox"/> NO Norway                                    |
| <input checked="" type="checkbox"/> CN China                                 | <input checked="" type="checkbox"/> NZ New Zealand                               |
| <input checked="" type="checkbox"/> CU Cuba                                  | <input checked="" type="checkbox"/> PL Poland                                    |
| <input checked="" type="checkbox"/> CZ Czech Republic                        | <input checked="" type="checkbox"/> PT Portugal                                  |
| <input checked="" type="checkbox"/> DE Germany                               | <input checked="" type="checkbox"/> RO Romania                                   |
| <input checked="" type="checkbox"/> DK Denmark                               | <input checked="" type="checkbox"/> RU Russian Federation                        |
| <input checked="" type="checkbox"/> EE Estonia                               | <input checked="" type="checkbox"/> SD Sudan                                     |
| <input checked="" type="checkbox"/> ES Spain                                 | <input checked="" type="checkbox"/> SE Sweden                                    |
| <input checked="" type="checkbox"/> FI Finland                               | <input checked="" type="checkbox"/> SG Singapore                                 |
| <input checked="" type="checkbox"/> GB United Kingdom                        | <input checked="" type="checkbox"/> SI Slovenia                                  |
| <input checked="" type="checkbox"/> GE Georgia                               | <input checked="" type="checkbox"/> SK Slovakia                                  |
| <input checked="" type="checkbox"/> GH Ghana                                 | <input checked="" type="checkbox"/> SL Sierra Leone                              |
| <input checked="" type="checkbox"/> GM Gambia                                | <input checked="" type="checkbox"/> TJ Tajikistan                                |
| <input checked="" type="checkbox"/> GW Guinea-Bissau                         | <input checked="" type="checkbox"/> TM Turkmenistan                              |
| <input checked="" type="checkbox"/> HR Croatia                               | <input checked="" type="checkbox"/> TR Turkey                                    |
| <input checked="" type="checkbox"/> HU Hungary                               | <input checked="" type="checkbox"/> TT Trinidad and Tobago                       |
| <input checked="" type="checkbox"/> ID Indonesia                             | <input checked="" type="checkbox"/> UA Ukraine                                   |
| <input checked="" type="checkbox"/> IL Israel                                | <input checked="" type="checkbox"/> UG Uganda                                    |
| <input checked="" type="checkbox"/> IS Iceland                               | <input checked="" type="checkbox"/> US United States of America                  |
| <input checked="" type="checkbox"/> JP Japan                                 |  |
| <input checked="" type="checkbox"/> KE Kenya                                 | <input checked="" type="checkbox"/> UZ Uzbekistan                                |
| <input checked="" type="checkbox"/> KG Kyrgyzstan                            | <input checked="" type="checkbox"/> VN Viet Nam                                  |
| <input checked="" type="checkbox"/> KP Democratic People's Republic of Korea | <input checked="" type="checkbox"/> YU Yugoslavia                                |
|  | <input checked="" type="checkbox"/> ZW Zimbabwe                                  |
| <input checked="" type="checkbox"/> KR Republic of Korea                     |  |
| <input checked="" type="checkbox"/> KZ Kazakhstan                            |  |
| <input checked="" type="checkbox"/> LC Saint Lucia                           |  |
| <input checked="" type="checkbox"/> LK Sri Lanka                             |  |
| <input checked="" type="checkbox"/> LR Liberia                               |  |

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

- ☐ .....
- ☐ .....

**Precautionary Designation Statement:** In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)

<b>Box No. VI PRIORITY CLAIM</b>		<input type="checkbox"/> Further priority claims are indicated in the Supplemental Box.		
Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country	regional application: regional Office	international application: receiving Office
item (1) 23 July 1997	PO 8196	AUSTRALIA		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): (1)

\* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.

**Box No. VII INTERNATIONAL SEARCHING AUTHORITY**

Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used): <b>ISA / AU</b>	Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority): Date (day/month/year)      Number      Country (or regional Office)
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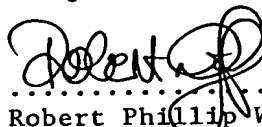
**Box No. VIII CHECK LIST; LANGUAGE OF FILING**

This international application contains the following number of sheets: request : 4 description (excluding sequence listing part) : 14 claims : 1 abstract : 1 drawings : 10 sequence listing part of description : - Total number of sheets : 30	This international application is accompanied by the item(s) marked below: 1. <input checked="" type="checkbox"/> fee calculation sheet 2. <input type="checkbox"/> separate signed power of attorney 3. <input type="checkbox"/> copy of general power of attorney; reference number, if any: 4. <input type="checkbox"/> statement explaining lack of signature 5. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s): 6. <input type="checkbox"/> translation of international application into (language): 7. <input type="checkbox"/> separate indications concerning deposited microorganism or other biological material 8. <input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form 9. <input type="checkbox"/> other (specify):
--	--

Figure of the drawings which should accompany the abstract: -	Language of filing of the international application: <b>ENGLISH</b>
---	---

**Box No. IX SIGNATURE OF APPLICANT OR AGENT**

*Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).*

  
 .....  
 Robert Phillip Wulff  
 Registered Patent Attorney of Griffith Hack  
 (for and on behalf of the Applicant)

For receiving Office use only	
1. Date of actual receipt of the purported international application: 3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application: 4. Date of timely receipt of the required corrections under PCT Article 11(2): 5. International Searching Authority (if two or more are competent): <b>ISA /</b>	2. Drawings: <input type="checkbox"/> received: <input type="checkbox"/> not received: 6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid.

For International Bureau use only
Date of receipt of the record copy by the International Bureau:

Form PCT/RO/101 (last sheet) (July 1998) See Notes to the request form



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>C02F 1/32, 1/74, C01B 13/32</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 99/05065</b> <b>(43) International Publication Date:</b> 4 February 1999 (04.02.99)
<b>(21) International Application Number:</b> PCT/AU98/00576 <b>(22) International Filing Date:</b> 22 July 1998 (22.07.98) <b>(30) Priority Data:</b> PO 8196 23 July 1997 (23.07.97) AU <b>(71) Applicants (for all designated States except US):</b> CRC FOR WASTE MANAGEMENT & POLLUTION CONTROL LIMITED [AU/AU]; The University of NSW, Botany Street, Gate 11, Kensington, NSW 2033 (AU). AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION [AU/AU]; New Illawarra Road, Lucas Heights, NSW 2234 (AU). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> KHOE, Ging, Hauw [AU/AU]; 125 Nicholson Pde, Cronulla, NSW 2232 (AU). ZAW, Myint [AU/AU]; 41 Delhi Street, Lidcombe, NSW 2141 (AU). PRASAD, Patricia, Salini [AU/AU]; 604 Woodville Road, Guildford, NSW 2161 (AU). EMETT, Maree, Therese [AU/AU]; 17 Stevens Street, Pennant Hills, NSW 2120 (AU). <b>(74) Agent:</b> GRIFFITH HACK; Level 8, 168 Walker Street, North Sydney, NSW 2060 (AU).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> PHOTO-ASSISTED OXIDATION OF INORGANIC SPECIES IN AQUEOUS SOLUTIONS <b>(57) Abstract</b> <p>A method for oxidising an inorganic species in an aqueous solution comprises the steps of: (i) supplying an oxidisable source of sulphur, and oxygen to the solution; and (ii) irradiating the solution with UV light such that both the inorganic and sulphur species are oxidised.</p>		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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EE	Estonia	LR	Liberia	SG	Singapore		



**PHOTO-ASSISTED OXIDATION OF INORGANIC SPECIES  
IN AQUEOUS SOLUTIONS**

**Field of the Invention**

5       The present invention relates to a method for  
oxidising inorganic species in aqueous solutions, and more  
particularly, to the treating of contaminants in e.g. human  
drinking water, and industrial waste waters and process  
liquors. However, it should be appreciated that the  
10       invention can be employed wherever it is necessary to  
oxidise an inorganic species in aqueous solutions for  
whatever reason.

**Background to the Invention**

      Dissolved sulphur dioxide or sulphite is usually  
15       considered to be a reducing agent. Further, it is known  
that the oxidation of sulphite is accelerated through  
exposure to UV radiation (Matthews, J.H. et.al.  
J.Am.Chem.Soc.1917,39, 635). Matthews teaches, however,  
that oxidation is retarded by the presence of trace amounts  
20       of various species. In addition, no change in the  
oxidation state of these species was observed.

      Many drinking water supplies across the world are  
contaminated by trace contaminants including arsenic, iron  
and manganese. World Health Organisation standards require  
25       very low levels of contaminants (for example arsenic-a 10  
ppb limit). The presence of manganese gives rise to "dirty  
water" problems and can result in soiling of clothes and  
staining of household fixtures when present in  
concentrations in excess of 20 ppb in drinking water.

30       Many waste waters and mineral processing liquors from  
industry also include arsenic, iron, manganese and cerium,  
and in the field of nuclear technology, uranium.

      As part of the removal process, chemical oxidants such  
as chlorine, ozone and permanganate are often used.  
35       However, these oxidants can give rise to harmful byproducts

such as chloroform, and the presence of residual permanganate can produce discoloured waters.

### Summary of the Invention

The present invention provides a method for oxidising an inorganic species in an aqueous solution comprising the steps of:

(i) supplying an oxidisable source of sulphur, and oxygen to the solution; and

(ii) irradiating the solution with UV light such that the species is oxidised.

In the present invention, oxygen is advantageously used as the oxidising agent, with no residual contaminating after-effects. Sulphur sources can be selected, (e.g. sulphite) such that in the oxidising procedure, a relatively benign product is produced (e.g. sulphate). Although the final product of using sulphite is a relatively benign dissolved sulphate, it is preferable to use it sparingly especially if an ion-exchange process is subsequently used to remove the contaminant (e.g. arsenic). In this case dissolved sulphate of no more than 25 mg/L is preferred in order to obtain effective arsenic(V) removal (sulphate and arsenate compete for sites on the ion-exchange material).

The oxidisable sources of sulphur can be  $\text{SO}_3^{2-}$ ,  $\text{S}_2\text{O}_3^{2-}$ ,  $\text{S}_4\text{O}_6^{2-}$ ,  $\text{SO}_2(\text{g})$ , aqueous  $\text{SO}_2$ , or  $\text{HSO}_3^-$ . However, sulphur dioxide and sulphite are preferred sources.

Typically the process is applied in the treatment of trace quantities of inorganic species but the process can also find application with more concentrated quantities of contaminants.

Typically the species oxidised includes one or more of arsenic, manganese, cerium and/or iron.

Typically the ultraviolet light employed has a wavelength of about 254nm. Radiation can be supplied continuously or in pulses. Furthermore, low, medium or high pressure mercury arc lamps can be used as the source

of the UV radiation. It was also noted that UV wavelengths of 254nm from a lamp source advantageously disinfected water so treated.

Typically the oxygen is sparged into the aqueous solution as air but other methods of addition are possible. As indicated above, the solution is typically a drinking water solution, an industrial waste water or process liquor etc.

Typically the pH of the solution is, if necessary, adjusted to be approximately neutral or basic.

#### **Brief Description of the Drawings**

Notwithstanding any other forms which may fall within the scope of the present invention, preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings and the following non-limiting examples. In the drawings:

Figure 1 is a graph that plots the increase in arsenic(V)-concentration and concomitant decrease in sulfite-concentration as a function of illumination time using a 15 W low-pressure mercury lamp. The corresponding change in arsenic(V) concentration in darkness is also shown. (Initial conditions: 1.7 litre of solution containing 470 ppb arsenic(III) in the presence of 10 mg/L sulfite, solution pH adjusted to 9 using sodium carbonate).

Figure 2 is a graph that plots the increase in arsenic(V) concentrations as a function of illumination time using a 15 W 254 nm lamp. (Initial conditions: 1.7 litre of solution containing arsenic(III) concentration of approximately 470 ppb, pH adjusted to 9 using sodium carbonate, initial sulfite concentrations varied from 0 to 12 mg/L).

Figure 3 is a graph that plots arsenic(V) concentrations as a function of elapsed time when solutions (1.7L) containing arsenic(III) at a concentration of 470 ppb, at various controlled pHs, were illuminated with a 15 W 254 nm lamp. Sodium sulphite solution was added at a

dose rate of 2 mg/L/min and air was sparged at a rate of 2.5 L/min. Data with no UV illumination (dark) are also shown.

Figure 4 is a graph that plots arsenic(V) concentrations as a function of elapsed time when a solution (1.7L) containing arsenic(III) at a concentration of about 20 mg/L, at pH 6.5, was illuminated with a 15 W 254 nm lamp. Sulphur dioxide gas was injected at a rate of about 0.02 L/min and air was sparged at a rate of 2.5 L/min. Data with no UV illumination (dark) are also shown.

Figure 5 is a graph that plots arsenic(V) concentrations as a function of elapsed time when solutions (1.7L) containing arsenic(III) concentration of 470 ppb, at pH 6.5, were illuminated with a 15 W 254 nm lamp. Sodium thio-sulphate solution was added at various dose rates (in mg/L/min) and air was sparged at a rate of 2.5 L/min. Data with no UV illumination (dark) are also shown.

Figure 6 is a graph that plots arsenic(V) concentrations as a function of elapsed time when a solution (1.7L) containing arsenic(III) at a concentration of 470 ppb, at pH 6.5, was illuminated with a 15 W 254 nm lamp. Sodium tetra-thionate solution was added at a dose rate of 2 mg/L/min and air was sparged at a rate of 2.5 L/min. Data with no UV illumination (dark) are also shown.

Figure 7 is a graph that plots residual manganese concentrations as a function of elapsed time when solutions (1.7L) containing manganese(II) concentration of about 500 ppb, at pH 8.5, were illuminated with a 15 W 254 nm lamp. Sodium sulphite solution was added at a dose rate of 2 mg/L/min and air was sparged at a rate of 2.5 L/min. The oxidised manganese was removed using a 0.025 micron membrane filter. To facilitate manganese removal, ferric chloride (6.2 mg Fe/L) was added in 2 of the 4 tests. Data with no UV illumination (dark) are also shown.

Figure 8 is a graph that plots residual manganese concentrations as a function of elapsed time when a

solution (1.7L) containing manganese(II) at a concentration of about 20 mg/L, at pH 9.5, was illuminated with a 15 W 254 nm lamp. Sodium sulphite solution was added at a dose rate of 80 mg/L/min and air was sparged at a rate of 2.5 L/min. Ferric chloride was added at 6.2 mg Fe/L to facilitate the manganese removal. Data with no UV illumination (dark) are also shown.

Figure 9 is a graph that plots iron(II) concentrations as a function of elapsed time when a solution (1.7L) containing iron(II) at a concentration of about 20 mg/L, at pH 2, was illuminated with a 15 W 254 nm lamp. Sodium sulphite solution was added at a dose rate of 20 mg/L/min, air was sparged at a rate of 2.5 L/min. Data with UV without sulphite, and no UV illumination (dark) are also shown.

Figure 10 is a graph that plots cerium(IV) concentrations as a function of elapsed time when a solution (1.7L) containing cerium(III) at a concentration of 20 mg/L, at pH 6.5, was illuminated with a 15 W 254 nm lamp. Sodium sulphite solution was added at a dose rate of 20 mg/L/min, air was sparged at a rate of 2.5 L/min. Data with UV illumination but without sulphite, and no UV illumination (dark) are also shown.

#### **Modes for Carrying Out the Invention**

Preferred forms of the present invention find application in the treatment of drinking water, waste waters and mineral processing liquors. It should be appreciated, however, that the invention has broader applications.

With drinking water treatment, it is desirable to remove trace oxidisable contaminants, such as arsenic and manganese. In at least preferred forms, contaminants are oxidised and then removed under neutral or slightly alkaline conditions.

In the treatment of waste waters and mineral processing liquors, it is desirable to neutralise and/or

remove (depending on the final use of the water or liquor) species such as arsenic, iron and manganese. In these applications, however, oxidation may take place in acid, neutral or alkaline conditions.

5 Manganese-related "dirty water" problems are a significant water quality issue to water supply authorities. It is understood that 40 per cent of public water supplies in the United States have manganese concentrations exceeding levels of 10-20ppb.

10 Manganese is also a problem in processed wastes in the milling of uranium ores and in acid mine drainage. Manganese is often present in the ore to be milled, and may be also introduced as an oxidant in the form of a pyrolusite ( $\text{MnO}_2$ ) which is an oxidant used in the leaching  
15 of uranium.

In industrial process liquors, it is necessary to oxidise various metal ions as part of the overall processing in the plant.

Details of various preferred process operating  
20 parameters are now described.

#### **Source of Radiant Energy**

Any source of radiant energy in the UV region of the electromagnetic spectrum was observed to be useful, provided that the radiation was absorbed by the dissolved  
25 sulphur compound which was acting as the photo-initiator of the process. Low pressure mercury arc lamps were used for the oxidation of dissolved arsenic(III), manganese(II), iron(II) and cerium(III). Typical UV wavelengths of less than 300nm were employed (preferably about 254nm).

#### **30 Choice of Photo-Absorber**

Dissolved sulphur species absorbed the supplied UV light and were oxidised by dissolved oxygen. These sulphur species were used up (oxidised) during the photochemical reaction. Dissolved sulphur(IV) species derived from the  
35 addition of sodium sulphite included  $\text{SO}_3^{2-}$ ,  $\text{HSO}_3^-$  or  $\text{H}_2\text{SO}_3$  depending on the pH value of the solution. The same

dissolved sulphur species were obtained by dissolving  $\text{SO}_2$  gas in water which gives aqueous  $\text{SO}_2$  which, in turn, converted to sulphurous acid ( $\text{H}_2\text{SO}_3$ ). Sulphurous acid dissociated to  $\text{HSO}_3^-$  and  $\text{SO}_3^{2-}$  at higher pH conditions.

- 5 Dissolved sulphite from sodium sulphite was used for the oxidation of manganese(II).

Other partially oxidised sulphur species (sulphur(VI) as in sulphate compounds having fully oxidised sulphur species) obtained from the dissolution of sodium  
10 thiosulphate or sodium tetrathionate were also used as the photo-absorber.

Furthermore, dissolved sulphite was obtained by sparging sulphur dioxide gas or a gas mixture of sulphur dioxide and air/oxygen/nitrogen into the solution. Thus,  
15 the forms of sulphur employable included  $\text{SO}_3^{2-}$ ,  $\text{SO}_{2(g)}$ , aqueous  $\text{SO}_2$ ,  $\text{HSO}_3^-$ ,  $\text{S}_2\text{O}_3^{2-}$  and  $\text{S}_4\text{O}_6^{2-}$ .

#### Source of Oxidant

Oxygen was the oxidant for the photochemical oxidation process. It was typically supplied at about 0.2  
20 atmospheres partial pressure by aerating the reaction mixture. Alternatively, oxygen was supplied by sparging a gas mixture of sulphur dioxide with air, or an oxygen/nitrogen mixture into the solution (or any other compatible gas source). Oxygen partial pressures greater  
25 than or less than 0.2 atm can also be used as appropriate.

Illumination was achieved by placing a lamp within a quartz envelope inside the reaction vessel (alternatively, the light can be directed from above the solution). Types of lamp used included a high or low pressure mercury arc  
30 lamp or a xenon arc lamp.

It was noted that where the UV source chosen emitted light at a wavelength at about or below 190 nm, ozone was generated from the dissolved oxygen; (ozone is a powerful oxidant which can oxidise arsenic(III) and manganese(II)).  
35 For the examples described below, non-ozone producing lamps were employed.

### Examples

Non-limiting examples will now be described.

#### Photo-Oxidation of Dissolved Arsenic(III)

A reaction mixture (1700 mL) containing 470 µg/L As(III) (typical concentrations in ground water in areas where arsenic is leached from the naturally occurring arsenic-containing minerals) and 10 mg/L of dissolved sulphite ( $\text{SO}_3^{2-}$ ) was prepared as follows: the sulphite stock solution was prepared by dissolving sodium sulphite salt in demineralised water; the arsenious acid (As(III)) solution was obtained by dissolving arsenic trioxide in warm, demineralised water. The pH of the reaction mixture was adjusted to 9 with the addition of sodium carbonate (because groundwaters typically have significant carbonate alkalinity). The solution was then aerated by the injection of fine bubbles of air.

In the absence of UV illumination, no significant oxidation of As(III) was observed (Figure 1). When a 15 W low pressure mercury lamp was switched on to illuminate the reaction mixture, the oxidation of As(III) and S(IV) proceeded rapidly (Figure 1).

The experiments were repeated using various initial concentrations of dissolved sulphite, namely from 0 to 12 mg/L of dissolved sulphite. As shown in Figure 2, the rate of As(III) oxidation was strongly dependent on the initial sulphite concentration when it was less than 8 mg/L. Figures 1 and 2 demonstrate that both UV light and dissolved sulphite were needed for the photo-oxidation reaction to occur.

Figure 3 shows that the arsenic oxidation rate was increased by the increase in the solution pH. During these test runs, the solution pH was controlled at the selected value using an automatic titrator which added sodium hydroxide solution when required. Sodium sulphite was added by the continuous injection of a stock solution (17 g/L of sulphite) at a precisely controlled flow rate using



a titrator in order to give a dose rate of 2 mg/L i.e. 0.2 mL/min of the stock solution was injected into the 1.7 L of reaction mixture. This method of sulphite dosing is more efficient than the procedure described for Figures 1 and 2 where the sodium sulphite was added in a single dose. It also simulates the procedure where SO<sub>2</sub> gas is used. Air was sparged at a rate of 2.5 L/min.

Sulphur dioxide gas was used instead of sodium sulphite as shown in Figure 4. Arsenic(III) was oxidised when sulphur dioxide and air was bubbled in the absence of UV illumination (auto oxidation process). However, the oxidation rate was accelerated when the reaction mixture was illuminated. It was observed that significant concentrations of dissolved sulphite were present in the reaction mixture indicating that an excess sulphur dioxide was sparged. Hence, the difference between the results of the 'light' and 'dark' experiments was not large as could be achieved.

Sodium thiosulphate can be substituted for sodium sulphite as shown in Figure 5. Similarly, sodium tetrathionate was used as the photo-absorber as demonstrated in Figure 6.

Actinometry determination using potassium ferrioxalate showed that a maximum of 6 Watts of 254 nm radiation produced by the 15 W lamp was absorbed by the reaction mixture. Total As and As(III) concentrations were determined using atomic absorption spectroscopy with hydride generation. Concentrations of As(V) in the reaction mixture were determined using the molybdenum blue spectrophotometric method (Johnson D. and Pilson M., Analytical Chimica Acta, 58, 289-299 (1972)). Sulphite concentrations were also determined spectrophotometrically (Humphrey R.E., Ward M.H. and Hinze W., Analytical Chemistry, 42, 698-702 (1970)).

### Photo-Oxidation of Dissolved Manganese(II)

A reaction mixture (1700 mL) containing 500 µg/L Mn(II) (typical concentrations in surface and ground water are less than 1 mg/L) and 10 mg/L  $\text{SO}_3^{2-}$ , was prepared as follows: the sulphite stock solution was prepared by dissolving sodium sulphite salt in demineralised water; the Mn(II) stock solution was obtained by dissolving  $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$  in demineralised water. The pH of the reaction mixture was 6.5 and it was aerated by the injection of fine bubbles of air.

After a 15 W low pressure mercury lamp was switched on to illuminate the reaction mixture for 2 minutes, the reaction mixture became cloudy because of the appearance of grey/black suspended particles indicating that an oxide of manganese had been formed. A 25 mL sample was collected and its pH (4 - 5) was adjusted to 7 using dilute sodium hydroxide solution in order to coagulate colloidal manganese oxide particles. After 30 minutes, to allow the precipitated grey/black particles sufficient time to coagulate, the sample was filtered using an Amicon unit fitted with 0.025 µm membrane. The dissolved Mn concentration in the filtrate was 22 µg/L. This indicates that most of the dissolved Mn(II) was oxidised to Mn(III)/Mn(IV) and precipitated as manganese oxide (which is black).

When the same procedures were repeated without illumination, the reaction mixture remained clear and colourless. A sample was taken after 30 minutes and subjected to the coagulation and filtration procedure. The manganese concentration in the filtrate was 505ppb (Table 1).

Dissolved manganese concentrations were analysed using ICP-MS, ICP-AES or atomic absorption spectroscopy with a graphite furnace.

The results of one SUCH procedure are summarised in

Table 1.

**Table 1****Residual manganese concentration in water after filtration.**

Concentration in parts per billion

5

Initial Concentration	511 ppb
After 2 min illumination at pH 6.5 in the presence of 10 mg/L sulfite	22 ppb
After 30 minutes without illumination	505 ppb

**Photo-Oxidation of Other Dissolved Compounds**

The above procedures can also be employed with the photo-oxidation of dissolved compounds such as Se(IV), CN<sup>-</sup>, Fe(II), Ni(II), V(IV), U(IV), and Ce(III). Oxidation can be demonstrated by making up a reaction mixture containing an appropriate concentration of one or more of these compounds. Dissolved sulphur species can be obtained from stock solution which can be prepared by dissolving either the equivalent sodium or calcium salt in water. The mixture can then be divided into three portions for a set of three tests:

1. No UV illumination. To the first portion of the reaction mixture, an appropriate amount of sulphite or sulphide is added from a concentrated stock solution. The mixture is aerated with a nitrogen-oxygen mixture of known oxygen partial pressure. Speciation of the oxidation state of the target substance and the sulphur at several time intervals was used to determine the reaction rate.
2. The second portion of the reaction mixture is aerated with the same oxygen/nitrogen gas mixture used in Test 1 and illuminated without the addition of a sulphur compound.

3. The final portion is aerated with the same addition of sulphite or sulphide as used in Test 1 and the light was then turned on to start the experiment. The oxidation rate is determined as above for As(III) and Mn(II).

Illumination can be achieved by placing a lamp either within an envelope inside the reaction vessel or such that the light radiates from above. Types of lamps used can include a high or low pressure mercury arc lamp, a Xenon arc lamp or a blacklight blue fluorescent tube.

It would be observed that the rate of oxidation of the target substance in Test 3 is greater than that in either Tests 1 or 2.

#### 15 **Procedure for Experiments Using Sulphur Dioxide Gas**

The photo-oxidation reaction can proceed just as well when sulphur dioxide gas is used instead of sulphite salt. In order to demonstrate this, for each target substance, a set of three tests can be performed as in the previous section. The reaction mixture can be sparged with a fine stream of gas bubbles. The partial pressure of oxygen, sulphur dioxide and nitrogen can be independently varied in the gas stream from 0 to 100%.

Test A Sulphur dioxide is added to the oxygen/nitrogen gas stream at a known partial pressure, in the absence of any illumination, and the rate of oxidation was determined by speciating the oxidation state of the target substance after several time intervals.

Test B The vessel is designed so that the second portion of the reaction mixture was illuminated with light from a lamp, in the absence of sulphur dioxide. The slow background oxidation rate (if any) is determined by speciating the target substance for oxidation state at several time intervals.

35 Test C The third portion of the reaction mixture is placed in the reaction vessel. Sulphur dioxide was added

to the gas stream and the lamp is switched on at the same time, to mark the beginning of the experiment. The sulphur dioxide partial pressure is the same as that in Test A and the illumination source and lamp intensity were the same as that in Test B.

The rate of oxidation of the target substance in Test C would be greater than that in Tests A or B.

The pH of the reaction mixture and the addition of sodium sulphite solution were controlled using automatic titrators as described above. The oxidation of manganese was evidenced by the appearance of grey/black suspended particles indicating that an insoluble oxide of manganese(III) or (IV) had been formed. Preliminary measurements using electron paramagnetic resonance spectroscopy confirmed that the concentration of dissolved Mn(II) decreased with the elapsed time of illumination.

The precipitated manganese particles were removed using an Amicon unit fitted with 0.025 micron membrane filter. As shown in Figure 7, the addition of ferric chloride solution to give a concentration of about 6 mg Fe/L in the reaction mixture improved the removal of manganese from solution. The residual manganese concentrations were analysed using ICP-MS, ICP-AES or atomic absorption spectroscopy with graphite furnace.

As shown in Figure 7, at pH 8.5, the rate of removal of manganese from solution was accelerated by the illumination of the reaction mixture using UV light from a low-pressure mercury lamp. The oxidation of a more concentrated solution of Mn(II) at pH 9.5 is depicted in Figure 8. Here, the dosing rate of sulphite was increased to 80 mg/L/min to account for the initial Mn(II) concentration of 20 mg/L.

#### **Photo-oxidation of Dissolved Iron(II) in Acid Conditions**

The oxidation of iron(II) was followed by periodically measuring the residual dissolved iron(II) concentration in the reaction mixture. This was determined

spectrophotometrically using ferrozine reagent (Stookey, Analytical Chemistry, Vol. 42, No. 7, 1970).

Figure 9 shows iron(II) concentrations as a function of elapsed time when a solution (1.7L) containing iron(II) at a concentration of about 20 mg/L, at pH2, was illuminated with a 15 W 254 nm lamp. Sodium sulphite solution was added at a dose rate of 20 mg/L/min, air was sparged at a rate of 2.5 L/min. The oxidation data with UV illumination but without sulphite indicated that the oxidation of Fe(II) by dissolved oxygen was accelerated by UV illumination. This was due to the fact that dissolved Fe(II), which is a mild photo-absorber of light at 254 nm wavelength, photo-initiated and sustained the oxidation reaction. Dissolved Fe(II) was oxidised in the presence of dissolved sulphite and oxygen without UV illumination (dark) (known as the auto-oxidation reaction).

#### **Photo-oxidation of Cerium(III)**

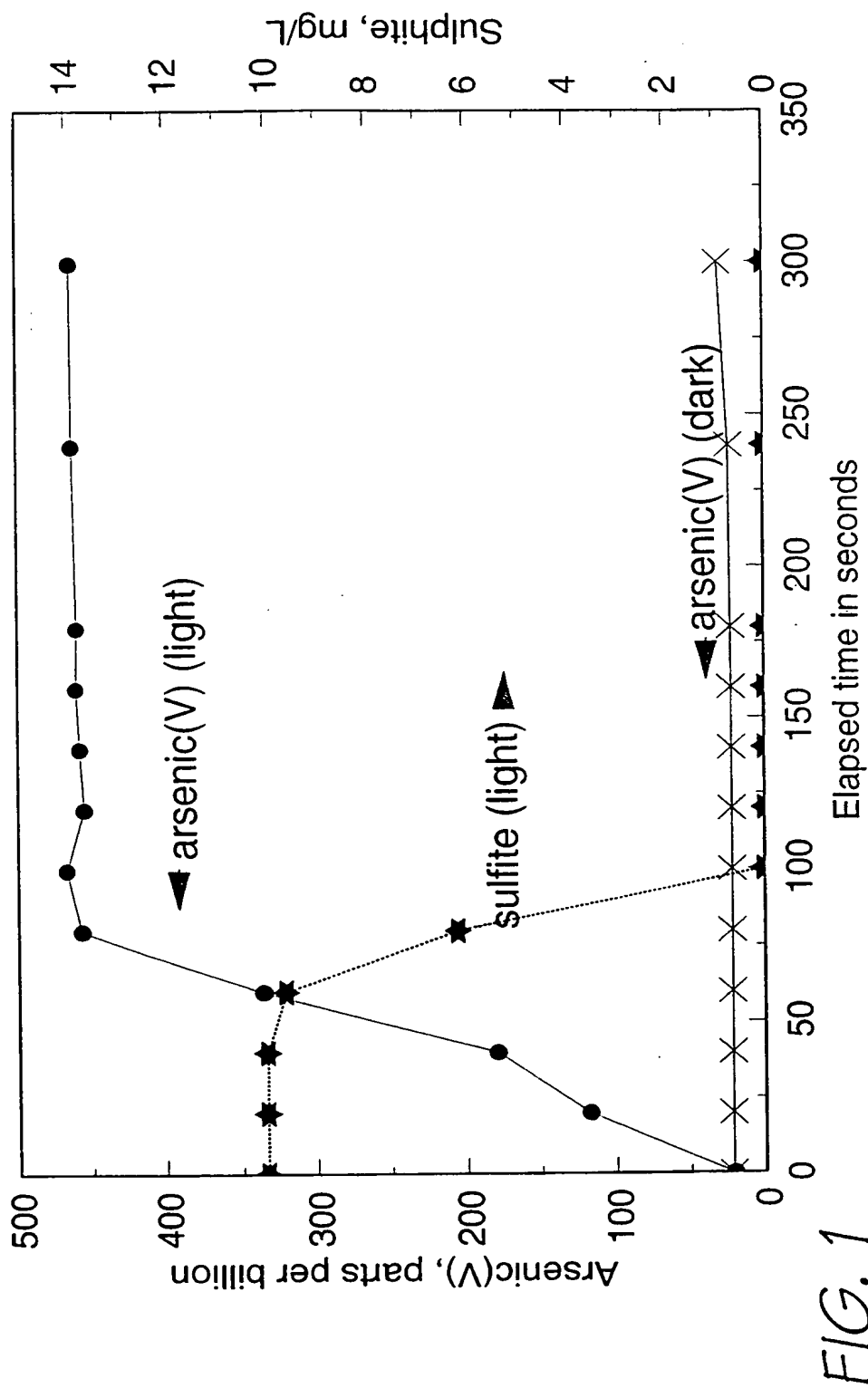
The oxidation of cerium(III) was followed by measuring the concentration of cerium(IV) in solution using a volumetric titration method (Vogel A.I. 'A text-book of quantitative inorganic analysis' third edition, Longmans 1961, page 318). Data from the three test runs, with UV illumination and sulphite dosing, with UV illumination but without sulphite dosing, and without UV illumination but with sulphite dosing are given in Figure 10.

As shown in Figure 10, unlike the case for iron(II), the auto-oxidation reaction (in the dark) was not sufficient to oxidise dissolved cerium(III). However, like iron(II), dissolved cerium(III) absorbed UV light at 254 nm and photo-initiated the oxidation reaction. The photo-oxidation reaction was clearly accelerated by the addition of 20 mg/L of sulphite per minute.

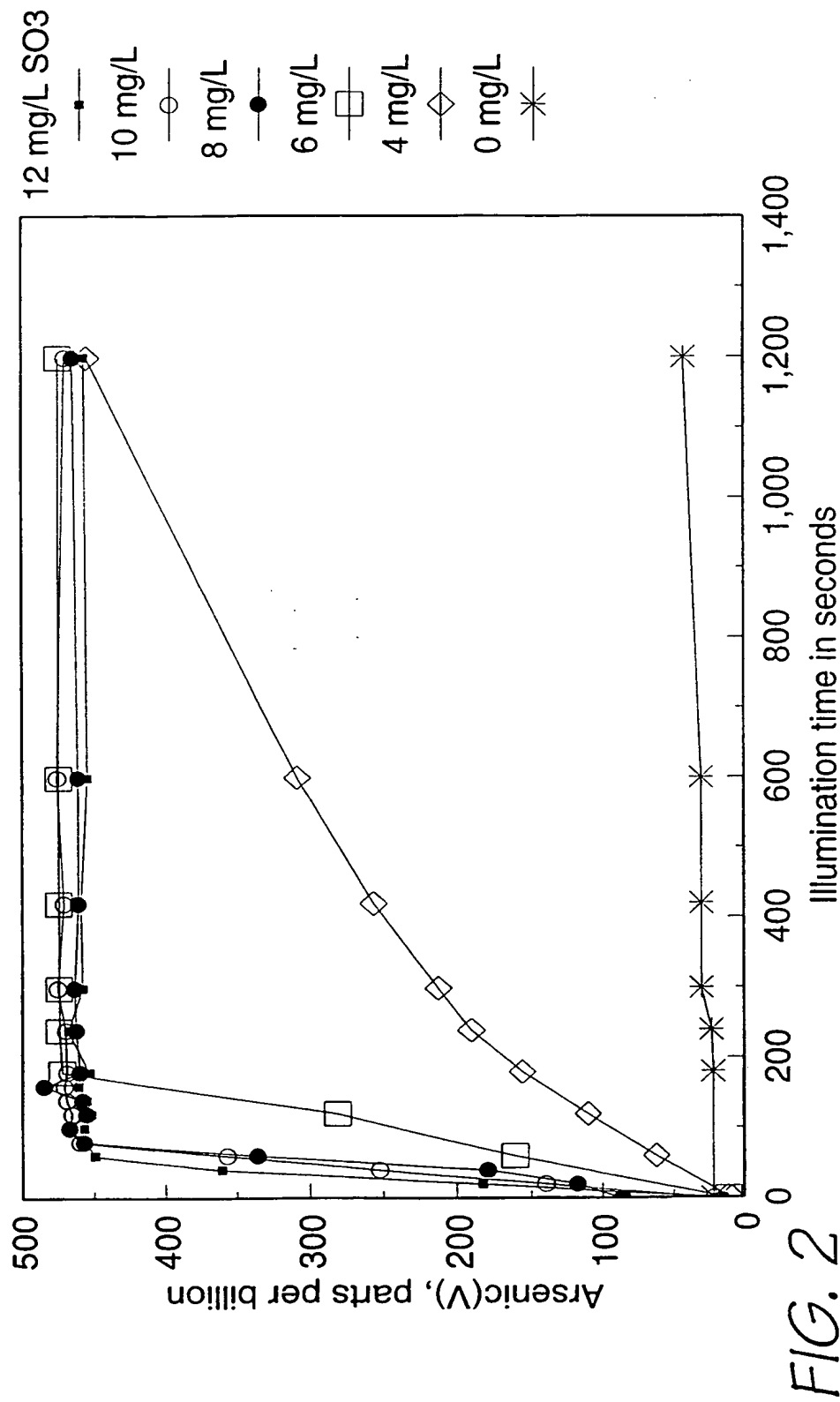
Whilst the invention has been described with reference to a number of preferred embodiments it should be appreciated that the invention can be embodied in many other forms.

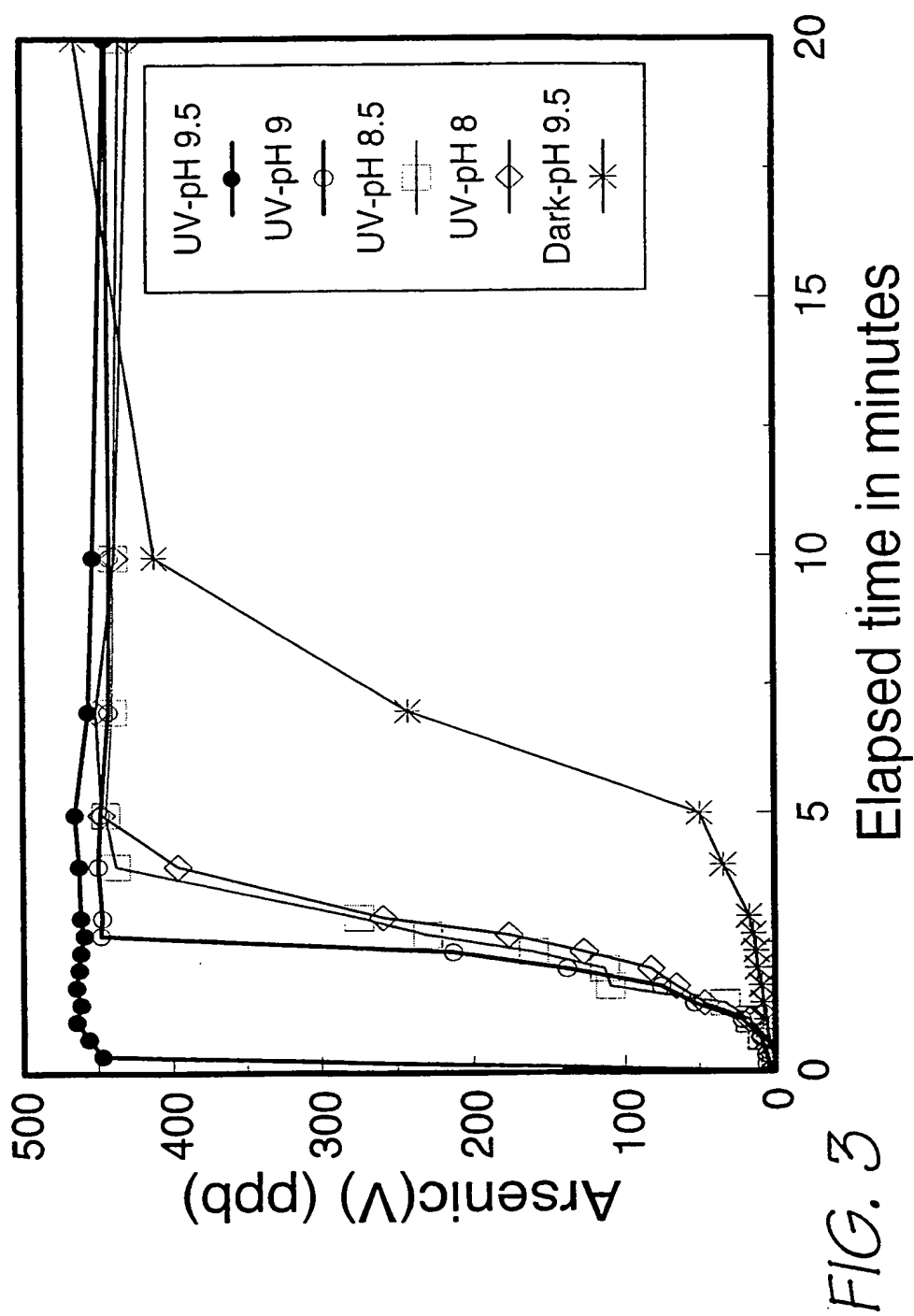
**CLAIMS:**

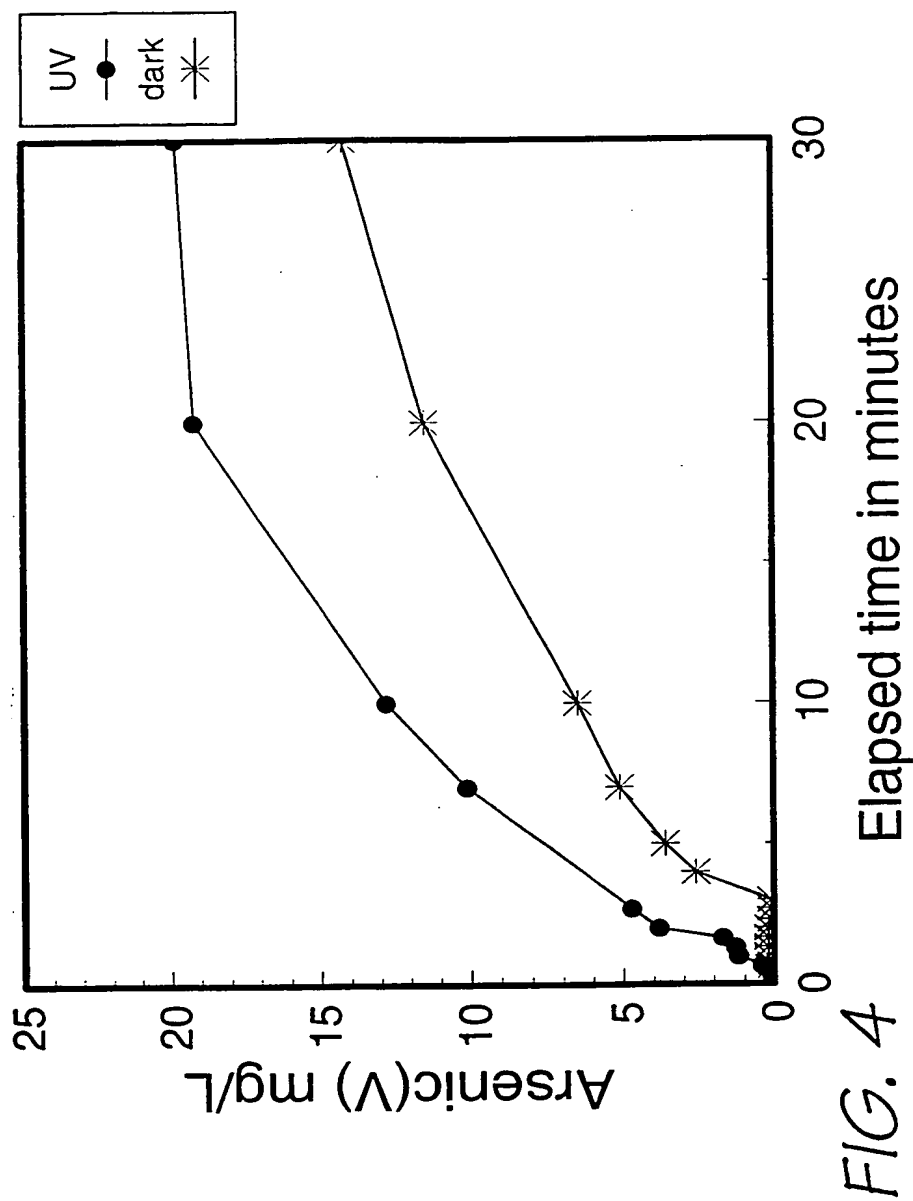
1. A method for oxidising an inorganic species in an aqueous solution comprising the steps of:
  - (i) supplying an oxidisable source of sulphur, and  
5 oxygen to the solution; and
  - (ii) irradiating the solution with UV light such that the species is oxidised.
2. A method as claimed in claim 1 wherein the oxidisable source of sulphur is  $\text{SO}_3^{2-}$ ,  $\text{SO}_2(\text{g})$ , aqueous  $\text{SO}_2$ ,  
10  $\text{HSO}_3^-$ ,  $\text{S}_2\text{O}_3^{2-}$ ,  $\text{S}_4\text{O}_6^{2-}$ .
3. A method as claimed in claim 1 or claim 2 wherein the inorganic species is present in the aqueous solution in trace quantities.
4. A method as claimed in any one of the preceding  
15 claims wherein the inorganic species is arsenic, manganese, cerium, and/or iron.
5. A method as claimed in any one of the preceding claims wherein the wavelength of UV light is less than 300nm.
- 20 6. A method as claimed in any one of the preceding claims wherein dissolved oxygen is derived from air.
7. A method as claimed in any one of claims 1 to 6 wherein dissolved oxygen is derived from a gas source with an oxygen partial pressure of about 0.2 atmospheres.
- 25 8. A method as claimed in any one of the preceding claims wherein the aqueous solution is one of: drinking water, industrial waste water, or an industrial process liquor.
9. A method for oxidising inorganic species in an  
30 aqueous solution substantially as herein described with reference to the Examples.











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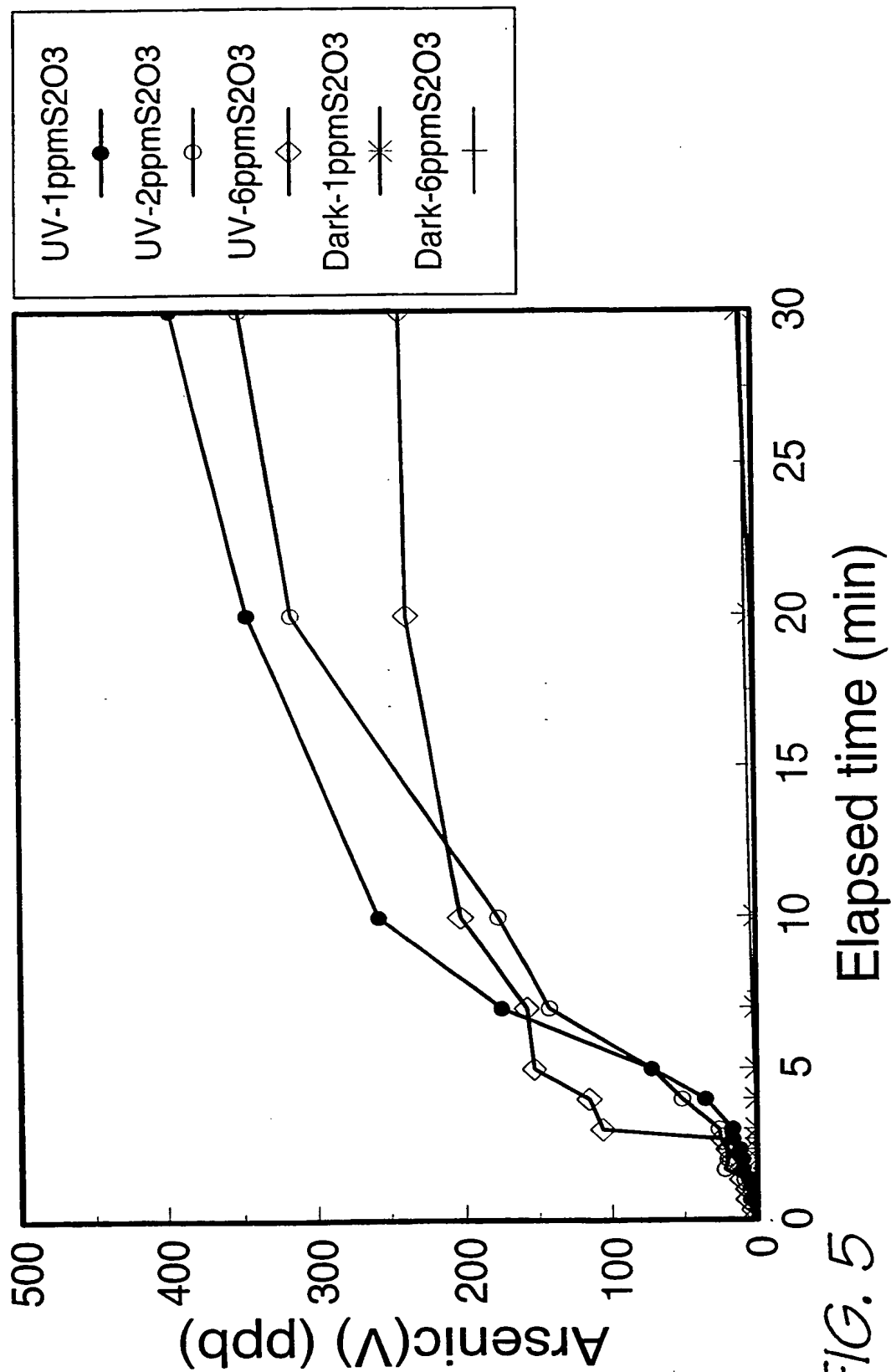
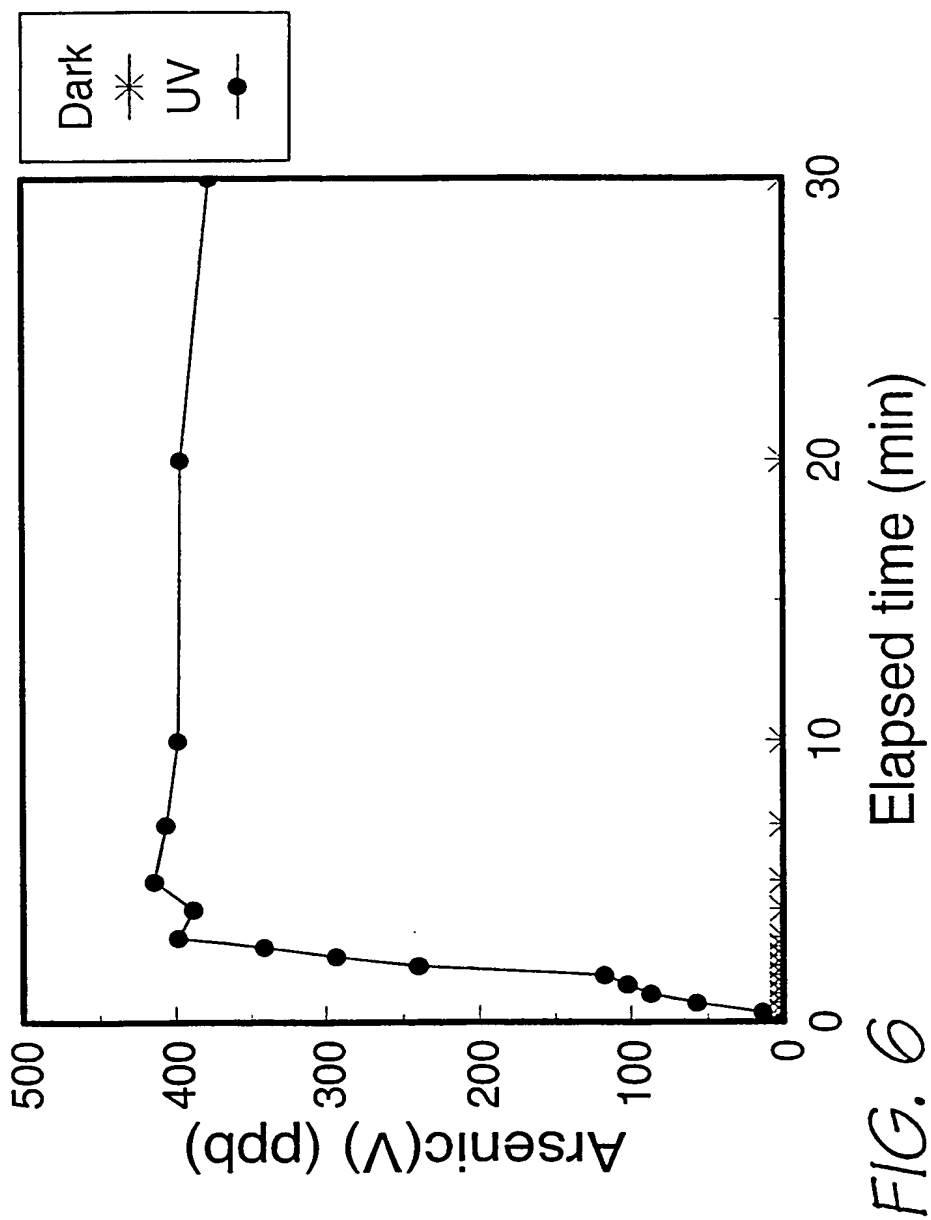
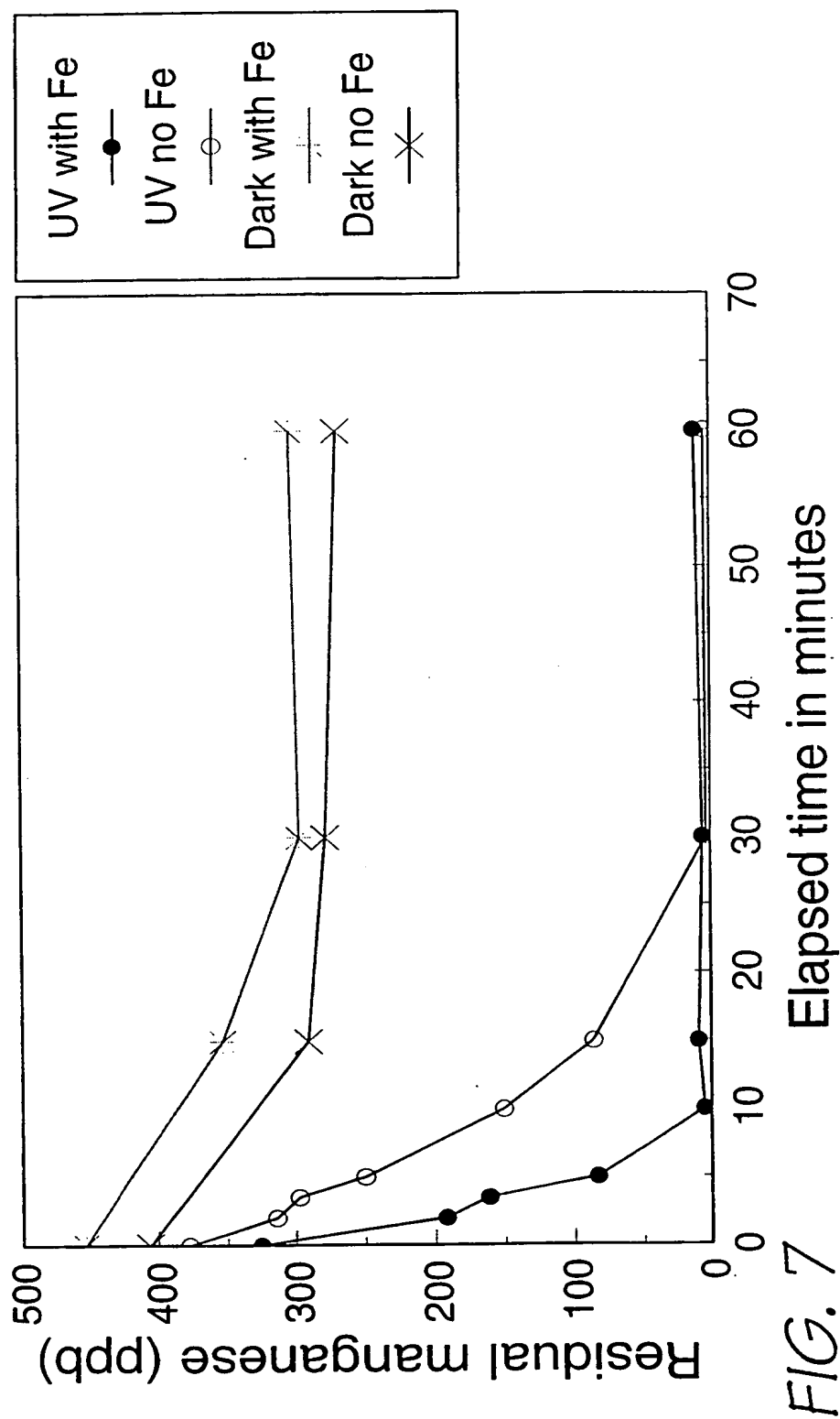


FIG. 5





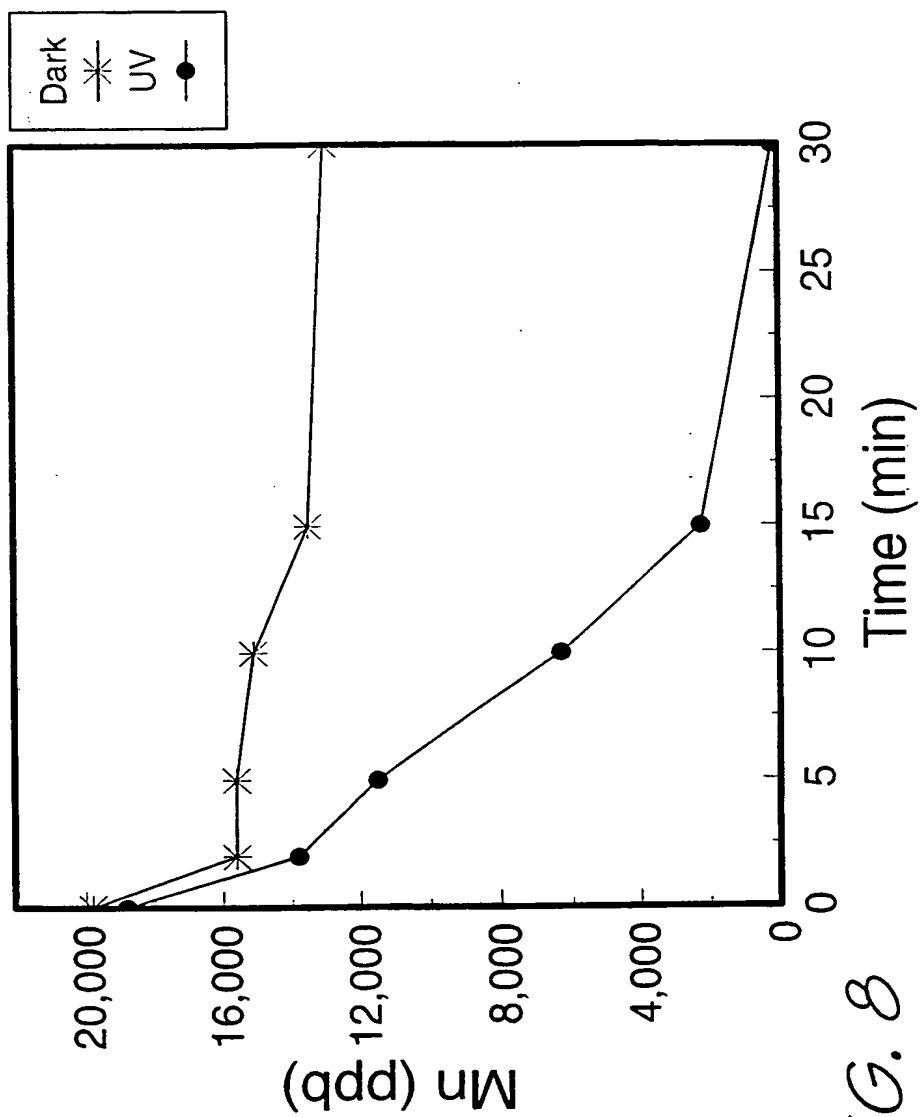


FIG. 8

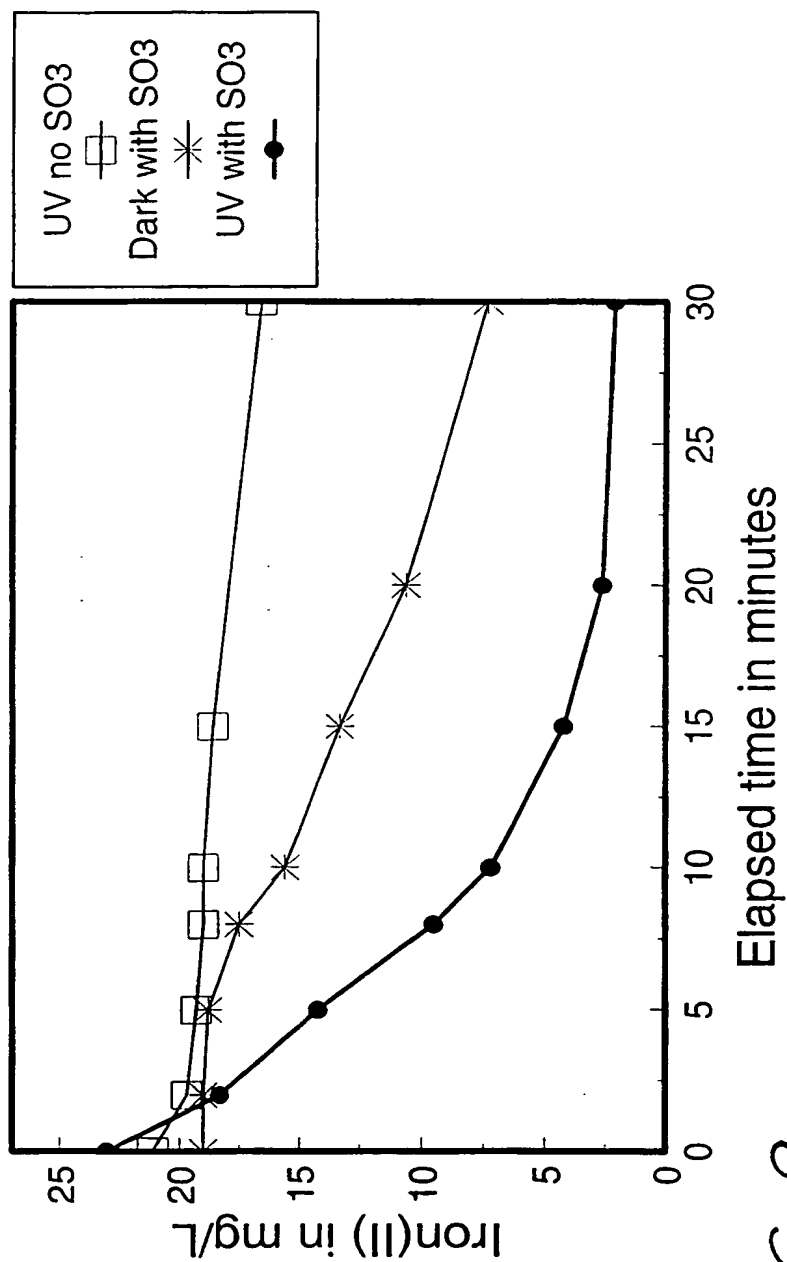
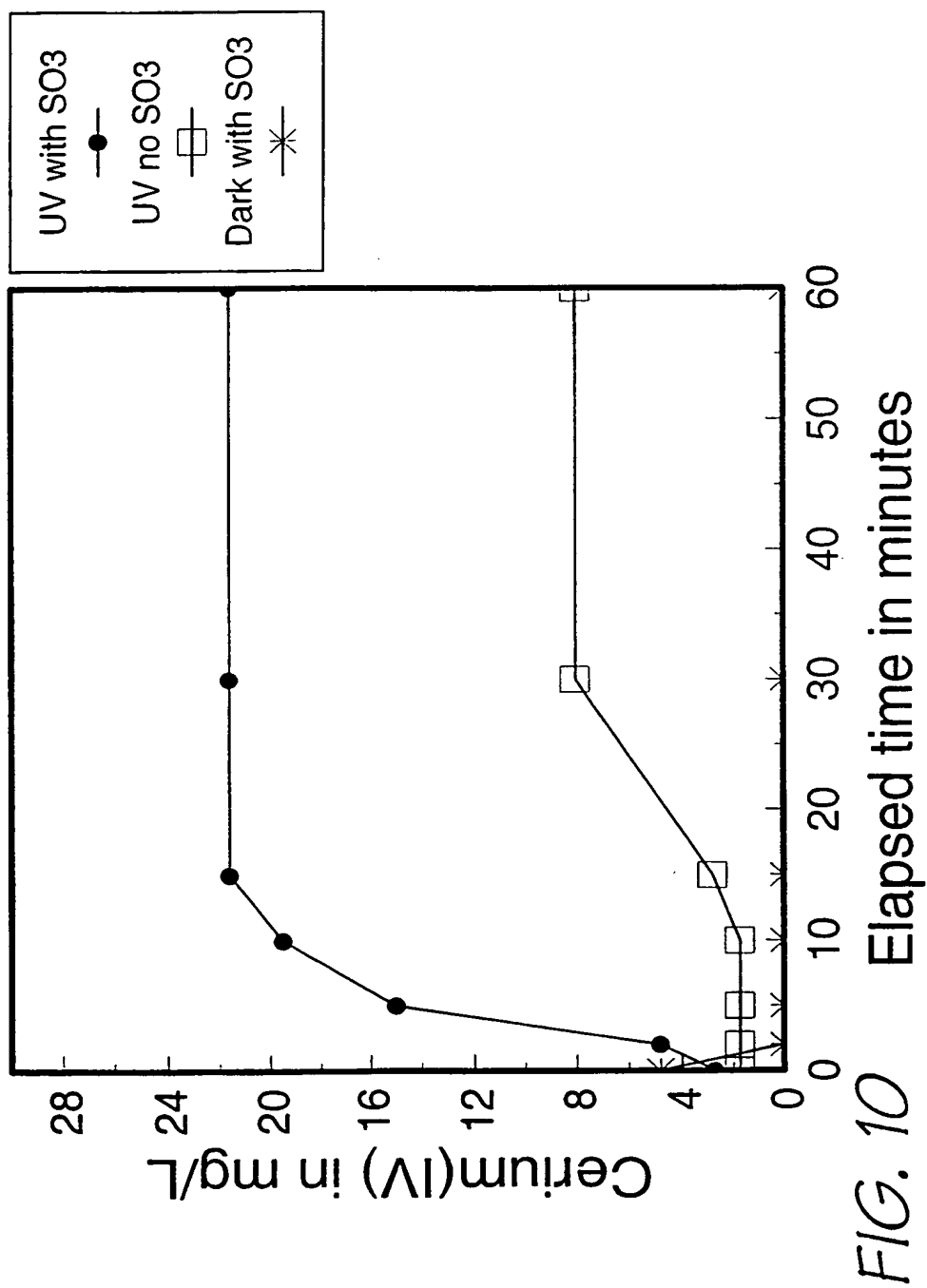


FIG. 9





# PATENT COOPERATION TREATY

## PCT

### INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/AU 98/00576</b>	International filing date ( <i>day/month/year</i> ) <b>22 July 1998</b>	(Earliest) Priority Date ( <i>day/month/year</i> ) <b>23 July 1997</b>
Applicant (1)    CRC for Waste Management & Pollution Control Ltd et al (2)    KHOE et al		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of **4** sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
  - a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
 

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
  - b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international application, the international search was carried out on the basis of the sequence listing:
 

☐ contained in the international application in written form.  
☐ filed together with the international application in computer readable form.  
☐ furnished subsequently to this Authority in written form.  
☐ furnished subsequently to this Authority in computer readable form.  
☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.  
☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished
2. ☐ **Certain claims were found unsearchable** (See Box I).
3. ☐ **Unity of invention is lacking** (See Box II).
4. With regard to the title,
 

☒ the text is approved as submitted by the applicant.  
☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract**,
 

☒ the text is approved as submitted by the applicant  
☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. The figure of the **drawings** to be published with the abstract is Figure No.
 

☐ as suggested by the applicant.                      ☒ None of the figures  
☐ because the applicant failed to suggest a figure  
☐ because this figure better characterizes the invention

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/AU 98/00576

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>				
Int Cl <sup>6</sup> : C02F 1/32 1/74 C01B 13/32				
According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b>				
Minimum documentation searched (classification system followed by classification symbols) IPC C02F 1/32, 1/72, 1/74, C01B 13/32				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPAT: (THIOSULPH: or THIOSULF: or SULF: or SULPH:) (OXIDAT: or OXYGEN: or OXIDIS: or OXIDIZ) (UV: or ULTRA () VIOLET: or IRRADIAT: or RADIAT:)				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X	US 5238581 A (FRAME et al) 24 August 1993	1-9		
X	US 5573676 A (MASSHOLDER et al) 12 November 1996	1-3, 6, 8, 9		
X	EP 759411 A1 (METALLGESELLSCHAFT AG) 26 February 1997	1-3, 6, 8, 9		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <span style="margin-left: 100px;"><input checked="" type="checkbox"/> See patent family annex</span>				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="width: 50%; vertical-align: top;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p> </td> </tr> </table>			<p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p>
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Date of the actual completion of the international search 10 September 1998		Date of mailing of the international search report <b>17 SEP 1998</b>		
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929		Authorized officer  <b>R.P. ALLEN</b> Telephone No.: (02) 6283 2134		

**INTERNATIONAL SEARCH REPORT**

International application No.

**PCT/AU 98/00576**

<b>C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
<b>Category*</b>	<b>Citation of document, with indication, where appropriate, of the relevant passages</b>	<b>Relevant to claim No.</b>
X	DE 4109872 A1 (MARTIN LUTHER UNIVERSITY) 1 October 1992	1-3, 6, 8, 9
Y	US 4537686 A (BORBELY et al) 27 August 1985	4
P, X	DE 19646555 A1 (DELTA UMWELT-TECHNIK GMBH) 30 April 1998	1-9
P, X	Derwent Abstract Accession No. 98-211144/19, Class D15, JP 10057973 A (MITSUI TOATSU CHEM INC) 3 March 1998	1-9
X	AU 14405/97 A1 (BIOTEZON GESELLSCHAFT) 17 July 1997	1-3, 6, 8, 9

### Information on patent family members

**PCT/AU 98/00576**

Patent Document Cited in Search Report				Patent Family Member			
US	5238581	US	5120453	CA	2070364	EP	572698
		JP	6000487	ZA	9204157		
US	5573676	DE	4214974	EP	639162	WO	9322249
EP	759411	JP	9103789				
AU	14405/97	WO	9725277	DE	19600774		

Form PCT/ISA/210 (extra sheet) (July 1998) coprso

# PATENT COOPERATION TREATY

From the:  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:  
  
Griffith Hack  
GPO Box 4164  
SYDNEY NSW 2001

## PCT NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing  
day/month/year 24 MAY 1999

Applicant's or agent's file reference  
RPW:CJ:FP9898

### IMPORTANT NOTIFICATION

International application No.  
PCT/AU 98/00576

International filing date  
22 July 1998

Priority date  
23 July 1997

Applicant  
(1) CRC for Waste Management & Pollution Control Ltd et al  
(2) KHOE et al

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translations to those Offices.
4. **REMINDER**  
  
The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).  
  
Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.  
  
For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide

Name and mailing address of the IPEA/AU  
AUSTRALIAN PATENT OFFICE  
PO BOX 200  
WODEN ACT 2606  
AUSTRALIA  
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Authorized officer

**R.P. ALLEN**

Telephone No. (02) 6283 2134

**INTERNATIONAL COOPERATION TREATY**  
**PCT**  
**INTERNATIONAL PRELIMINARY EXAMINATION REPORT**  
(PCT Article 36 and Rule 70)

Applicant's or agent's file reference RPW:CJ:FP9898	<b>FOR FURTHER ACTION</b>	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International application No.  PCT/AU 98/00576	International filing date (day/month/year)  22 July 1998	Priority Date (day/month/year)  23 July 1997
International Patent Classification (IPC) or national classification and IPC  Int. Cl. <sup>6</sup> C02F 1/32, 1/74, C01B 13/32		
Applicant (1) CRC for Waste Management & Pollution Control Ltd et al (2) KHOE et al		

1.	This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.																								
2.	This REPORT consists of a total of 5 sheets, including this cover sheet.  <input type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).  These annexes consist of a total of      sheet(s).																								
3.	This report contains indications relating to the following items:  <table style="width: 100%;"> <tr> <td style="width: 5%;">I</td> <td style="width: 5%; text-align: center;"><input checked="" type="checkbox"/></td> <td>Basis of the report</td> </tr> <tr> <td>II</td> <td style="text-align: center;"><input type="checkbox"/></td> <td>Priority</td> </tr> <tr> <td>III</td> <td style="text-align: center;"><input type="checkbox"/></td> <td>Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</td> </tr> <tr> <td>IV</td> <td style="text-align: center;"><input type="checkbox"/></td> <td>Lack of unity of invention</td> </tr> <tr> <td>V</td> <td style="text-align: center;"><input checked="" type="checkbox"/></td> <td>Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</td> </tr> <tr> <td>VI</td> <td style="text-align: center;"><input checked="" type="checkbox"/></td> <td>Certain documents cited</td> </tr> <tr> <td>VII</td> <td style="text-align: center;"><input checked="" type="checkbox"/></td> <td>Certain defects in the international application</td> </tr> <tr> <td>VIII</td> <td style="text-align: center;"><input type="checkbox"/></td> <td>Certain observations on the international application</td> </tr> </table>	I	<input checked="" type="checkbox"/>	Basis of the report	II	<input type="checkbox"/>	Priority	III	<input type="checkbox"/>	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability	IV	<input type="checkbox"/>	Lack of unity of invention	V	<input checked="" type="checkbox"/>	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement	VI	<input checked="" type="checkbox"/>	Certain documents cited	VII	<input checked="" type="checkbox"/>	Certain defects in the international application	VIII	<input type="checkbox"/>	Certain observations on the international application
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VII	<input checked="" type="checkbox"/>	Certain defects in the international application																							
VIII	<input type="checkbox"/>	Certain observations on the international application																							

Date of submission of the demand 22 February 1999	Date of completion of the report 19 May 1999
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. (02) 6285 3929	Authorized Officer  R.P. ALLEN Telephone No. (02) 6283 2134

**I. Basis of the report****1. With regard to the elements of the international application:\***

- ☒ the international application as originally filed.
- ☐ the description,        pages , as originally filed,  
                                 pages , filed with the demand,  
                                 pages , filed with the letter of .
- ☐ the claims,        pages , as originally filed,  
                                 pages , as amended (together with any statement) under Article 19,  
                                 pages , filed with the demand,  
                                 pages , filed with the letter of .
- ☐ the drawings,        pages , as originally filed,  
                                 pages , filed with the demand,  
                                 pages , filed with the letter of .
- ☐ the sequence listing part of the description:  
                                 pages , as originally filed  
                                 pages , filed with the demand  
                                 pages , filed with the letter of

**2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.  
These elements were available or furnished to this Authority in the following language which is:**

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

**3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, was on the basis of the sequence listing:**

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

**4. ☐ The amendments have resulted in the cancellation of:**

- ☐ the description,        pages
- ☐ the claims,        Nos.
- ☐ the drawings,        sheets/fig

**5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).\*\***

\* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

\*\* Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report



**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement****1. Statement**

Novelty (N)	Claims 1-9	YES
	Claims	NO
Inventive step (IS)	Claims 1-9	YES
	Claims	NO
Industrial applicability (IA)	Claims 1-9	YES
	Claims	NO

**2. Citations and explanations (Rule 70.7)**Citations

- (a) US 5238581 A (FRAME et al) 24 August 1993
- (b) US 5573676 A (MASSHOLDER et al) 12 November 1996
- (c) EP 759411 A1 (METALLGESSELLSCHAFT AG) 26 February 1997
- (d) AU 14405/97 A1 (BIOTEZON GESELLSCHAFT) 17 July 1997
- (e) DE 4109872 A1 (MARTIN LUTHER UNIVERSITY) 1 October 1992
- (f) US 4537686 A (BORBELY et al) 27 August 1985

Novelty & Inventive StepClaims 1-9  
claims.

None of the citations or obvious combination thereof disclose all of the features of any one of these

**VI. Certain documents cited****1. Certain published documents (Rule 70.10)**

Application No. Patent No.	Publication date (day/month/year)	Filing date (day/month/year)	Priority date ( valid claim) (day/month/year)
DE 19646555 A1	30 April 1998	29 October 1996	29 October 1996
JP 10057973 A	3 March 1998	14 August 1996	14 August 1996

**2. Non-written disclosures (Rule 70.9)**

Kind of non-written disclosure	Date of non-written disclosure (day/month/year)	Date of written disclosure referring to non-written disclosure (day/month/year)

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:

Claim 9 does not conform with Rule 6.2(a) because it relies on reference to the description.

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